METHOD FOR PROVIDING REMOVABLE WELD BACKING

FIELD OF THE INVENTION

This invention relates generally to the field of welding, and, more particularly, to a method for welding objects having a restricted access region behind a region to be welded.

BACKGROUND OF THE INVENTION

Weld backings are used to temporarily provide support for weld material deposited in a region being welded, to prevent, for example, a weld root from sagging below the welded region. An uncontrolled weld root may result in varying weld thickness and sharp notches in the weld requiring further machining that may be difficult and time consuming to perform. Furthermore, complex weld root profiles may be difficult to obtain without the use of a weld backing. Typically, a mechanical support is used for holding a heat resistant material against a backside of a region to be welded. Once the weld has cooled sufficiently, the backing can be removed, leaving a smooth weld root. Typically, ceramics, fiberglass tape, solid metal, and weld metal deposited using a tungsten gas process are used for weld backings. However, irregularly shaped objects having restricted access to the backside of regions to be welded pose problems when attempting to provide weld backings in a conventional manner. In particular, objects having relatively complex structures defining irregular cavities with restricted access have been difficult to weld while maintaining a desired weld root profile.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more apparent from the following description in view of the drawings that show:

FIG. 1 is a partial cross-sectional view of an object having a confined access region filled with a removable backing material.

FIG. 2 is a partial cross-sectional view of an object having a confined access region filled with a removable backing including a pre-formed weld backing.

DETAILED DESCRIPTION OF THE INVENTION

The inventors of the present invention have innovatively realized that welding of objects having backside access that is restricted by a structure defining a cavity may be accomplished by at least partially filling the cavity proximate a region to be welded with a fugitive backing material. For purposes of this invention, the term fugitive backing material means a type of material that is provided at one stage of fabrication, a state of material is changed, a fabrication step is performed, the state of the material is changed a second time, and the material is subsequently removed by a process during a later stage of fabrication. Generally, a method of welding such objects includes filling at least a portion of the cavity directly below the region with a fugitive backing material, welding the region, and then removing the fugitive backing material from the cavity. FIG. 1 is a partial cross-sectional view of an exemplary object 10 having a limited backside access region restricted by structure defining a cavity 12 below a region 14 to be welded. Prior to welding, the cavity 12 may be filled with a removable, or fugitive, backing material 16. In an aspect of the invention, the cavity 12 may include an opening 22 positioned remote from the region 14 to be welded, to allowing removal of the fugitive backing material 16 through the opening 22 after welding. For example, restricted backside access objects requiring welding repair, such as turbine blades, turbine vanes, or turbine transition panels, may include cooling hole openings allowing limited backside access to a cavity to allow removal of a fugitive backing material after welding.

In one form, the fugitive backing material 16 may include a fusible material, such as metal powder or a brazing compound. Accordingly, a portion of the fusible material 16 facing the region 14 to be welded may become part of a weld 24 after welding of the region 14 is complete. In another aspect, the fugitive backing material 16 may include a refractory material, such as fused silica, alumina, or quartz, that does not become a part of the weld 24 during welding and, therefore, may be completely removed from the cavity after welding.

A powdered material may be used for the fugitive backing material 16. For example, the object 10 may be positioned so that the region 14 to be welded opens in an upward direction. The cavity 12 may then be filled with the powdered material and the region 14 welded, such as by laser or electron beam welding. If necessary, a plug may be provided to block the opening 22 to prevent the powdered material from exiting

the opening 22 under the force of gravity. In an aspect of the invention, the powdered material may be compacted in the cavity 12. The inventors have experimentally determined that a welding process such as gas tungsten arc or plasma arc welding may require the use of a binder mixed with the powdered backing material to provide a fugitive backing material 16 that is less likely to be displaced than a powdered material when welding. For example, a binder such as sodium silicate or hydrolyzed ethyl silicate may be added to the powdered material to achieve a desired viscosity, so that the mixed material remains in place after being packed in the cavity 12. Accordingly, the mixed material may be mixed to a desired viscosity suitable for packing into the cavity 12 without extending into the region 14 to be welded regardless of the orientation of the object with respect to gravity. The mixed material may be prevented from extending into the region 14 to be welded during packing, such as by a plug conforming to the dimension of the weld region. After the plug is removed, the mixed material may retain its packed configuration without extruding into the region 14. In an aspect of the invention, a liquid form of the binder may be mixed with the powdered material to create a relatively higher viscosity mixture that may be poured into the cavity and allowed to harden into a solid state.

After the cavity 12 has been filled with the fugitive backing material 16, the region 14 may be welded so that a weld root 26 of a weld 24 assumes the profile of a surface 20 of the fugitive backing material 16 exposed to the region 14 to be welded. After welding of the region 14, the fugitive backing material may then be removed through the opening 22, for example, by a chemical leaching process as would be appreciated by a skilled artisan. The leaching process may include injecting, into the filled cavity 12, a chemical capable of reducing the viscosity of the fugitive backing material 16 so that the fugitive backing material 16 may be made to flow out of the cavity 12 through the opening 22. In the case of a powdered material, the material may be simply removed by orienting the object so that the force of gravity causes the material to flow out through the opening 22. After removal of the fugitive backing material 16, the cavity may be flushed with, for example, steam, water, or compressed air to ensure that fugitive backing material 16 is thoroughly removed. In addition, if a material, such as fused silica, is used as a fugitive backing material 16, a chemical etching process, as known in the art, may be used to remove any remaining material from the cavity 12.

The above process may be further explained in terms of states of the fugitive backing material during the steps of the process. For example, an installation state of the fugitive backing material may include states such as a loose granular state, a liquid state, or a paste state, so that insertion of the fugitive backing material into the cavity of is easy to accomplish. A rigid state, for example, existing after transformation from the installation state, may include a gravity held state, a compacted state, a hardened state, or a cured state sufficiently rigid for supporting weld formation. A removable state may include the resulting state of the fugitive backing material after a process of, for example, melting, sublimation, dissolving, or releasing pressure or a resistance to gravity, so that the fugitive backing material is made easy to remove.

In another aspect of the invention, the fugitive backing material 16 may comprise multiple layers of material. For example, the object 10 may be positioned so that the opening 22 opens in an upward direction (that is, inverted from the view shown in FIG. 1, so that the region 14 to be weld is at the bottom of the figure). A first layer 18 of a fugitive backing material 16, such as described above, may then be placed, for example, via the opening 22, in a first portion 11 of the cavity 12 adjacent to the region 14 to be welded so that a second portion 13 remains void. If necessary, a plug may be provided to block the opening 22 to prevent the fugitive backing material 16 from exiting the region 14. The first layer 18 may then be compacted in the cavity 12. A second layer 28 of fugitive backing material 16, such as metal powder, alumina, or wax, may then be added via the opening 22 to a second portion 12 of the cavity remaining void above the first layer 18. The second layer 28 may then be compacted in the cavity 12. Advantageously, the second layer 28 may be protected from a welding process by the first layer 18, so that a backing material having a lower melting point than the material used in the first layer 18 may be used. Accordingly, a material such as wax may be used, allowing removal of the second layer 28 of material from the cavity 12 using, for example, a sublimation, dissolving, or melting process, instead of a chemical leaching process that may be required with other materials. After the cavity 12 is filled with the second layer 28, the region 14 may be welded, and the fugitive backing material 16 may removed after welding. The second layer 28 may be removed from the cavity 12 using a removal process appropriate for the type of material used. After the second layer 28

is removed, the first layer 18 may then be removed using a removal process appropriate for the material forming the first layer 18.

In another aspect, a fugitive, pre-formed weld backing may be placed in a first portion of a cavity directly under a region to be welded, and a second portion of the cavity directly under the pre-formed weld backing may be filled with a fugitive filler. FIG. 2 is a partial cross-sectional view of an object 30 having a confined access region, or cavity 32 filled with a fugitive backing 34 including a pre-formed weld backing 36 adjacent to a region 42 to be welded. The pre-formed weld backing 36 may be sufficiently rigid so that it maintains its shape when installed in the cavity 32. As shown in FIG. 2, the pre-formed weld backing 36 may comprise an upper surface 38 having a shape complementary to a desired shape of a weld root 40. Accordingly, relatively complex profiles, such as may be required in an interior portion of a turbine blade or vane having turbulators or cooling passages adjacent to a region to be welded, may be formed in the weld root 40 using the pre-formed weld backing 36. In an aspect of the invention, the pre-formed weld backing 36 may be formed from a refractory material, such as silicate glass, quartz glass, or other materials known for use in casting. The pre-formed weld backing 36 may be sized so that it can be removed intact from the an opening 44 in the cavity 32 after welding, or be formed from a refractory material capable of being removed from the cavity 32, for example, by chemical leaching. In an aspect of the invention, the pre-formed backing 36 may be held in place adjacent the region to be welded 42 by a fugitive filler 46, for example, comprising the same material as used in the second layer 28 of FIG. 1 described above. The fugitive filler 46 may be held in place by gravity during welding, or may be mixed with a binder, as described earlier, for packing into the cavity 32, thereby allowing welding from any angle. After the region 42 is welded, the fugitive filler 46 may be removed from the opening 44, followed by removal of the pre-formed backing 36, leaving a weld 48 with a weld root 40 having a shape complementary to the upper surface 38 of the pre-formed weld backing 36.

While the preferred embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.